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CERTIFIED IN PLANNING AND INVENTORY MANAGEMENT

MODULE 3: DEMAND

APICS

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Module 3 Overview

Demand

- Section A: Demand Management
- Section B: Sources of Demand/Forecasting
- Section C: Forecast Performance

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SECTION A:
DEMAND MANAGEMENT

APICS

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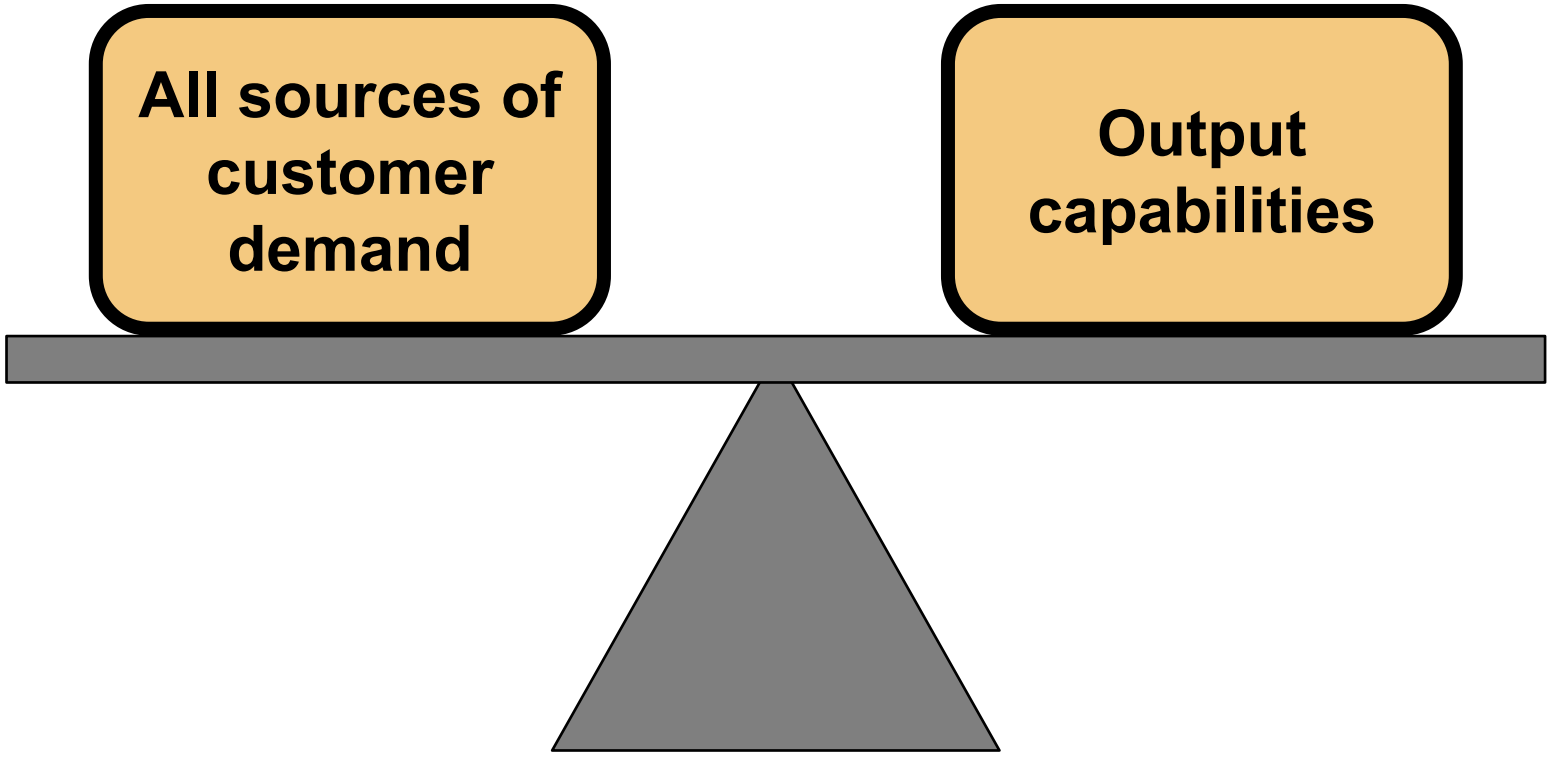
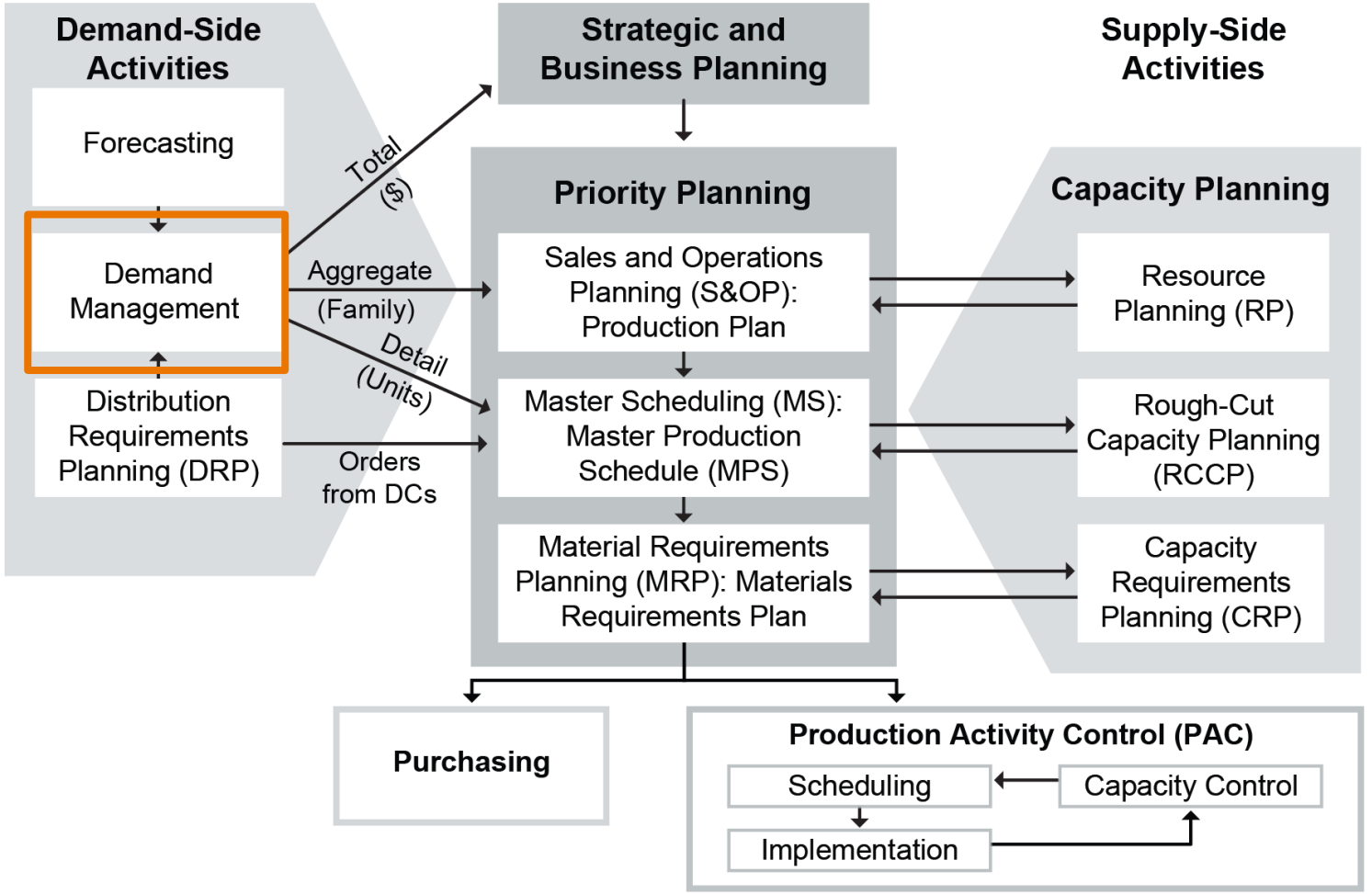
Section A Learning Objectives

- Demand-side activities in MPC
- Demand planning: planning, communicating, influencing, and prioritizing demand
- Principles of and inputs to demand management
- Seven “rights”
- Customer relationship management
- Setting customer service policies, safety stock levels, and performance targets
- Measuring order delivery performance
- Influencing demand to align with supply
- Marketing promotions and promotion life cycle
- Quality function deployment, voice of the customer, concurrent engineering, modular design, design for manufacturability/maintainability
- Product configuration and changes

S&OP and Master Scheduling Balance Demand



Demand Management in Manufacturing Planning and Control



Demand Management Activities

- Forecasting
  - Identifying market trends and patterns
- Identifying and reconciling demand sources
  - Customer segments
  - Unmet demands
  - Special requests
  - Items with erratic demand
- Distinguishing
  - Forecast versus manufacturing plans
  - Independent versus dependent demand
- New products/features
- Customer service levels and safety stock
- Order entry
- Communications

Data Reliability

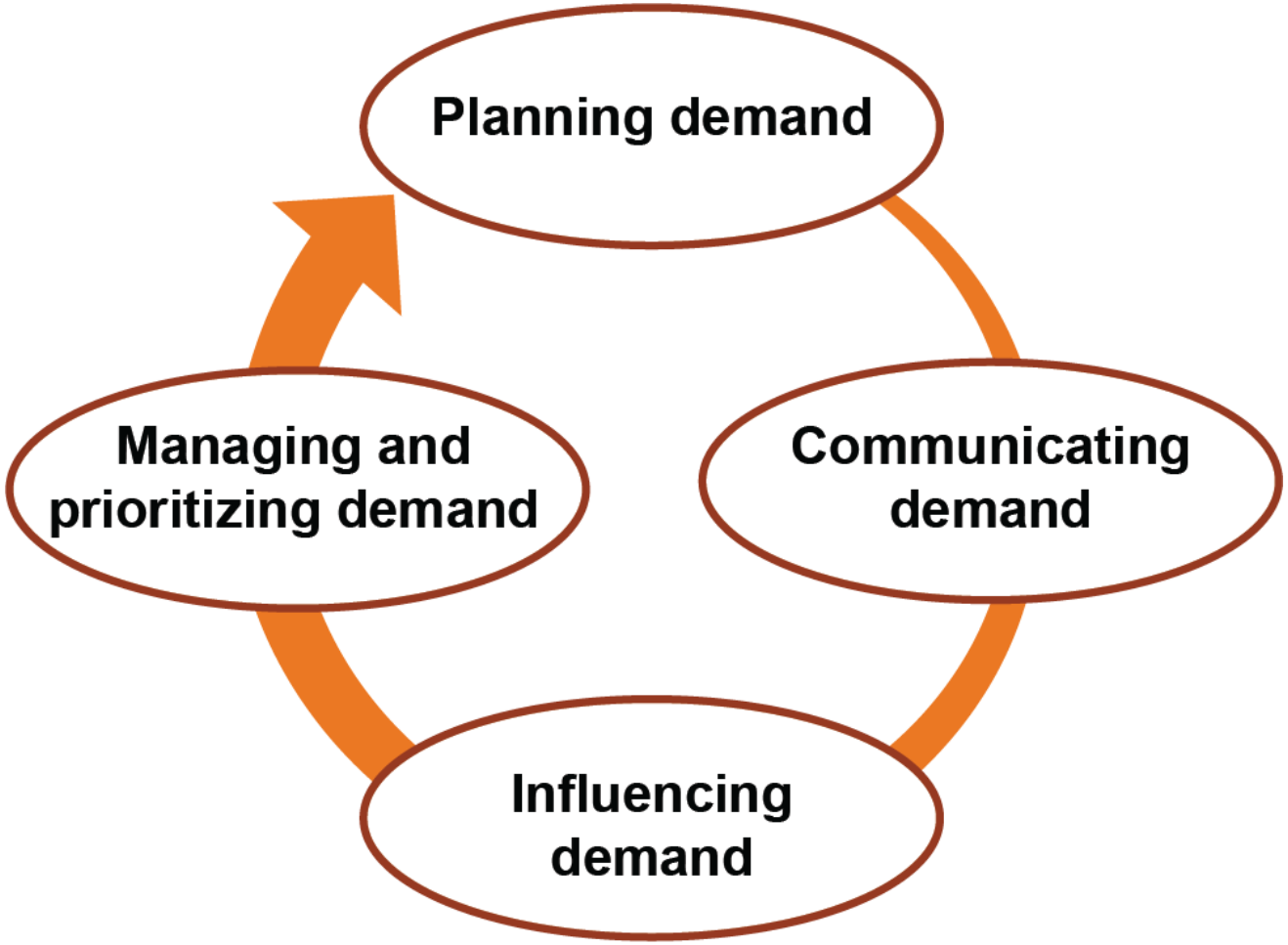
Forecasts are

- Not accurate (prediction)
- More on target the larger the group measured
- Best when used with a forecast error measuring technique
- More accurate the shorter the time period.

Inputs, calculations, and outputs checked for

- Errors in inputs, e.g., mixed units of measure, gaps, or exceeding minimum or maximum values
- Calculation errors: wrong formula or formula errors
- Unusual or unexpected trends needing investigation

Demand Management Process



The “Rights” of Customer Service

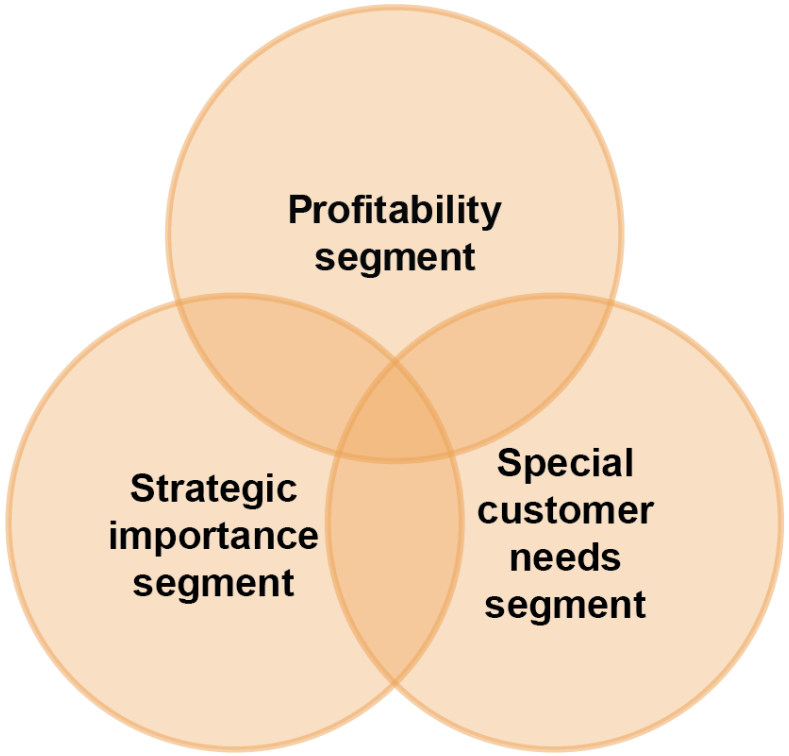
- The customer is always right.
- Customer-oriented organizations balance
  - Customer needs and wants
  - Organization’s strategic and business objectives.

The seven “rights” of customer service

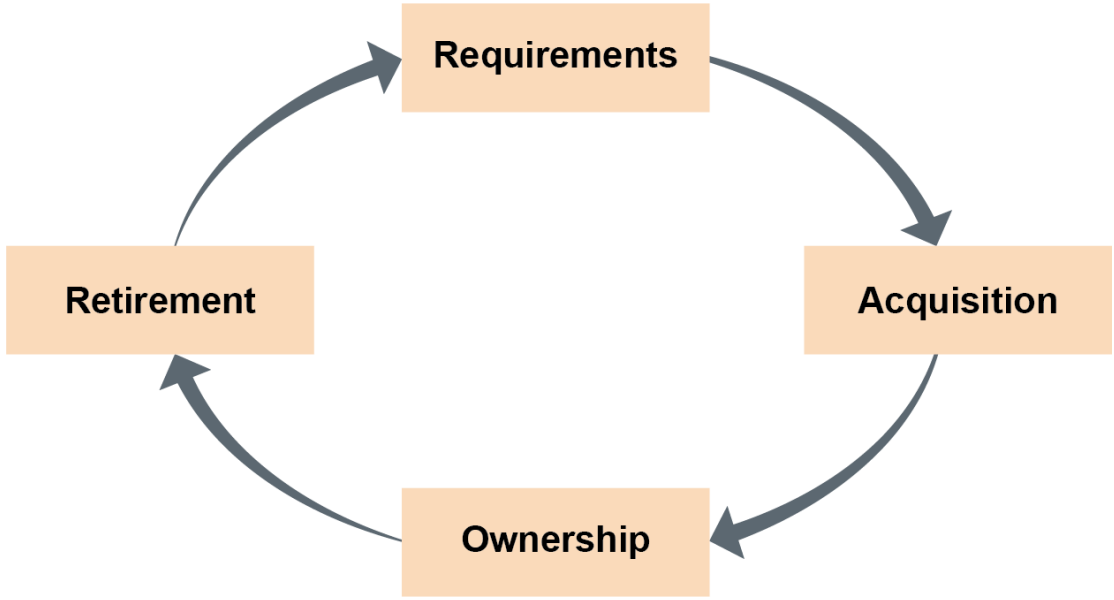
- Right customers
- Right goods and services
- Right price
- Right quality
- Right quantity
- Right time
- Right place

CRM: Philosophy of Putting the Customer First

Criteria for customer segmentation



Customer service life cycle



Defining Customers and Product-Service Parameters

Which customer segments?

- Industrial
- Consumer
  - Market segments
- Institutional
- Government

How will we reach them?

- Sales channels

What products/services?

- Product positioning
- Number of lines
- Price/market share/profit
- Quality
- Brand name or generic
- Packaging
- Returns policy

Customer Service

Cycle Steps	Examples of Key Activities
Customer inquiry, order	Request price and availability.
Order entry	▪ Check price and inventory available-to-promise. ▪ Configure as necessary. ▪ Promise and send order confirmation to customer. ▪ Create sales order in system. ▪ Reserve or allocate items to specific sales orders.
Shipping and delivery	▪ Consolidate and route shipments. ▪ Prepare pick lists. ▪ Prepare bills of lading and packing slips. ▪ Send advance ship notices.
Invoicing	▪ Prepare invoices. ▪ Transmit electronically or by other means.

Order Promising

Available-to-promise (ATP)

- Response to customer order inquiries

Capable-to-promise (CTP)

- Committing orders against available capacity and inventory
- Multiple supply sites
- Uses finite scheduling model
- Considers constraints
- Less expediting needed

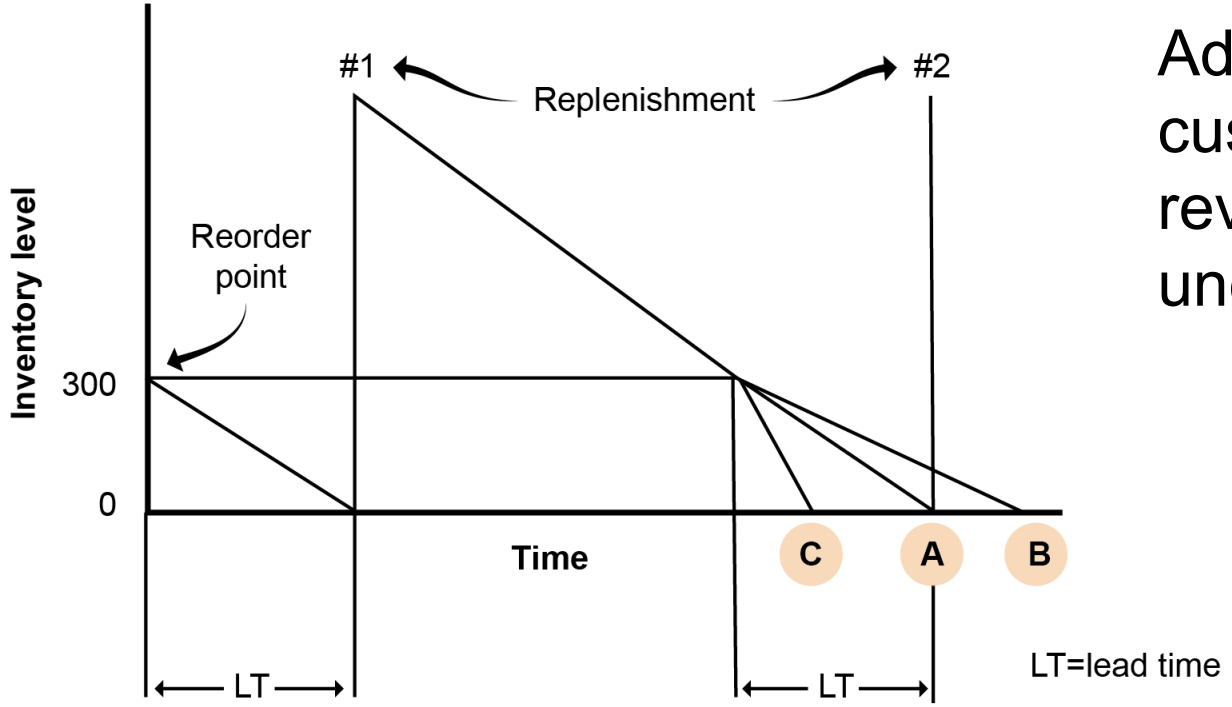
Abnormal demand

- Demand in any period that is outside the limits established by management policy

Customer Service Policies

- Customer focus
- Service levels
- Performance measurement
- Systems support
- Customer interface
- Culture
- Top management support
- Integration with strategic goals

Safety Stock



Additional inventory to prevent customer dissatisfaction and loss of revenue caused by demand and supply uncertainty

Point A: Zero inventory level is reached at replenishment; no stockout.

Point B: Zero inventory level is not reached before replenishment occurs; no stockout.

Point C: Zero inventory level is reached before replenishment; stockout!

Internal Communications

Communication among processes/subprocesses

- S&OP
- CRM
- Master scheduling
- Demand management
- Order management
- Order visibility

Patterns and preferences

- Purchasing patterns
- Shipping preferences

Visibility data sources

- Transaction records
- Sales representatives
- Field service representatives
- Market intelligence

Differences in Communications by Environment

	MTO/ETO	ATO	MTS
S&OP	Engineering detail and demand forecasts	Product family mix and demand forecasts	Demand forecasts
MPS	Final configurations	Actual demand and mix forecasts	Actual demand
Customers	Delivery date and design status	Delivery date and configuration issues	Next inventory replenishment

Customer Value and Service Metrics

Satisfaction rankings

- Most common tool used to measure customer satisfaction is surveys.

Lifetime customer value

- Decrease marketing cost.
- Easier to satisfy over time.
- Opportunity for additional revenue and profit.

Service levels by segment

- Level of service and organizational commitment to attaining that level varies by segment.

Order Delivery Performance Metrics

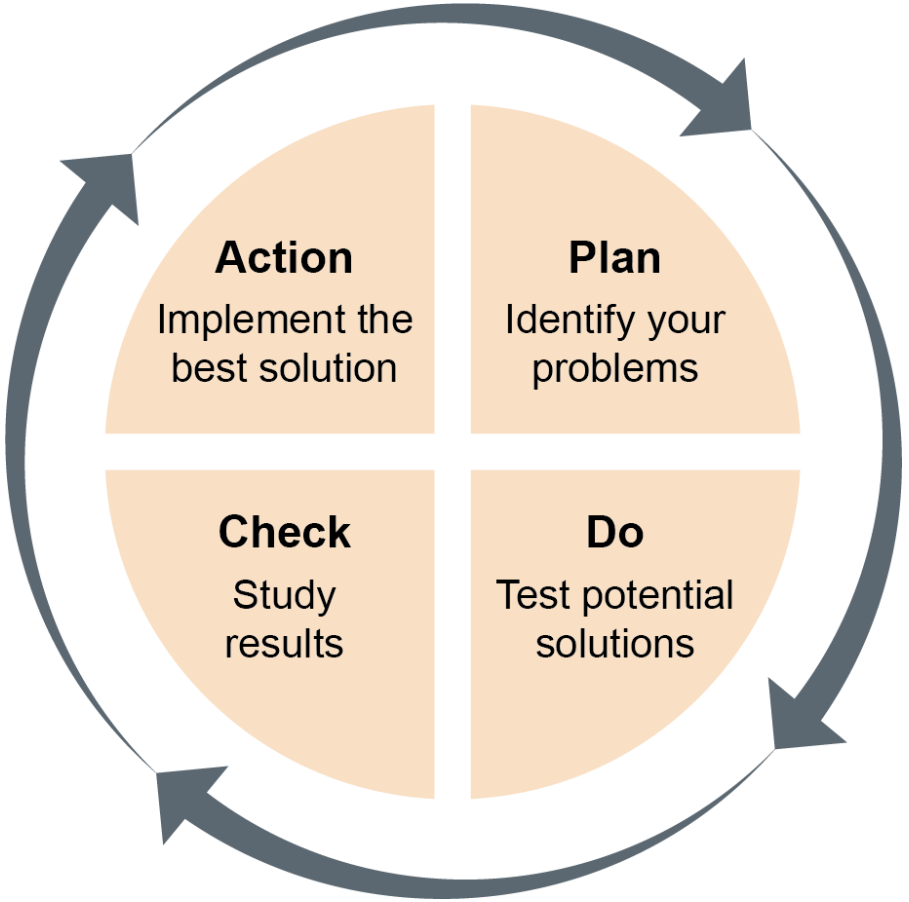
Additional metrics

- Manufacturing or retail environment impact on delivery performance
- Cash-to-cash cycle time
- Return on supply chain fixed assets

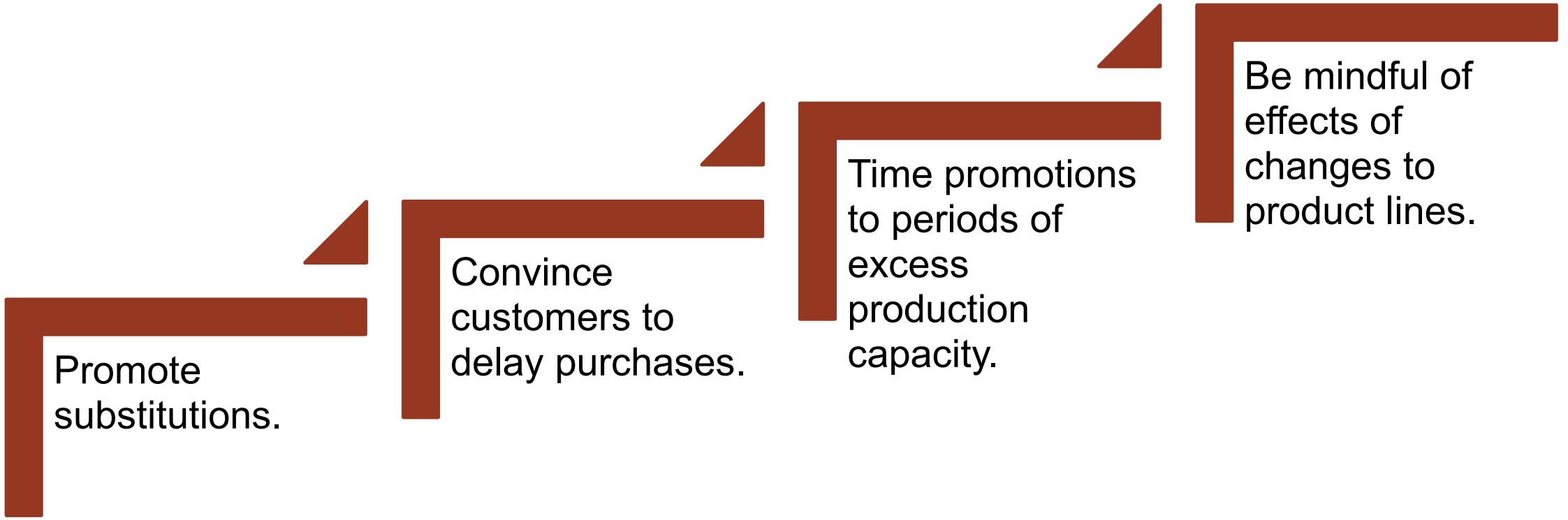
Attribute	Metrics
Reliability	▪ Perfect order fulfillment ▪ Delivered on time ▪ Delivered in full ▪ Correct condition ▪ Correct place
Responsiveness	▪ Order fulfillment cycle time ▪ Order entry time ▪ Dwell time for future dated orders ▪ Make, distribute, transport time
Agility	▪ Upside supply chain flexibility ▪ Upside supply chain adaptability ▪ Downside supply chain adaptability ▪ Overall value at risk
Cost	▪ Supply chain management cost ▪ Total cost to serve

Using PDCA for Planning and Influencing Demand

- **Plan**
  - Develop budget, schedule, tasks, and targets.
- **Do**
  - Launch, manage, and retire products.
- **Check**
  - Review and analyze performance.
- **Action**
  - Address variances, replan.



Prioritizing Demand



Influencing Product Designs

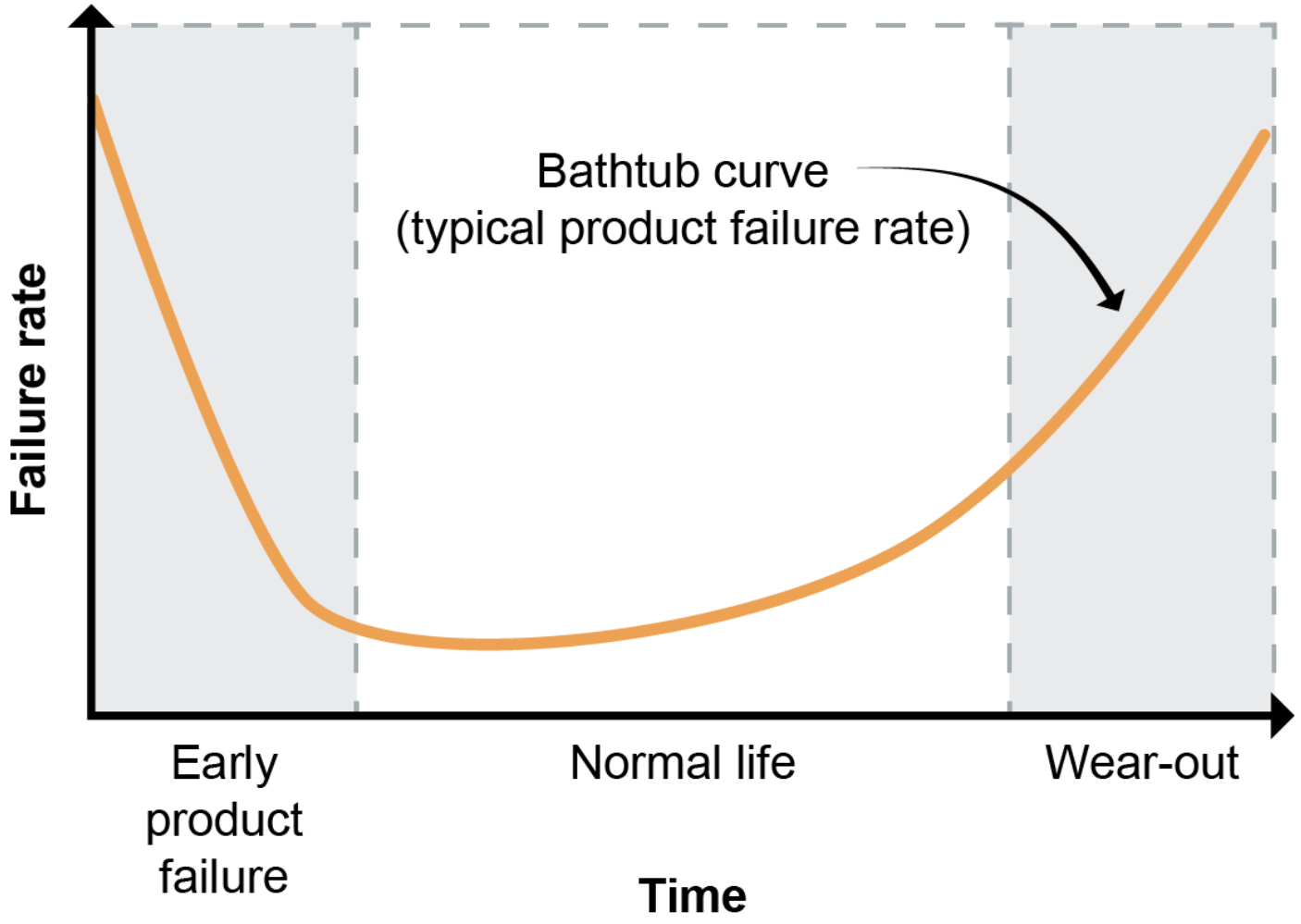
Quality function deployment

- Capture the voice of the customer.
- Use multidisciplinary teams.
- Improve planning.

Participative design/engineering (concurrent engineering)

- Meet internal/external customer needs.
- Consider all inputs together for fewer product/process design changes.
- Compress time from concept to introduction.
- Prevent quality and reliability problems.
- Reduce cost.

Bathtub Curve



Design for Manufacturability and Maintainability

Tradeoffs

- Reliability vs. maintainability
- Modular vs. nonmodular construction
- Repair vs. disposal
- Built-in vs. external test equipment
- Person vs. machine

Identifying Engineering Changes

Type of Change	Product Issue/Reason for Change	Action Required
Mandatory	▪ Failure to function ▪ Safety issue ▪ Legal compliance	▪ Immediate ▪ Engineering change notice ▪ Design review board process
Phased-in/ optional	▪ Product improvement or correction ▪ Customer request ▪ Cost reduction ▪ Process improvement	▪ Phase-out or modification of existing products ▪ Review of options for effectivity date ▪ Engineering change notice ▪ Design review board process

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SECTION B:
SOURCES OF DEMAND/
FORECASTING

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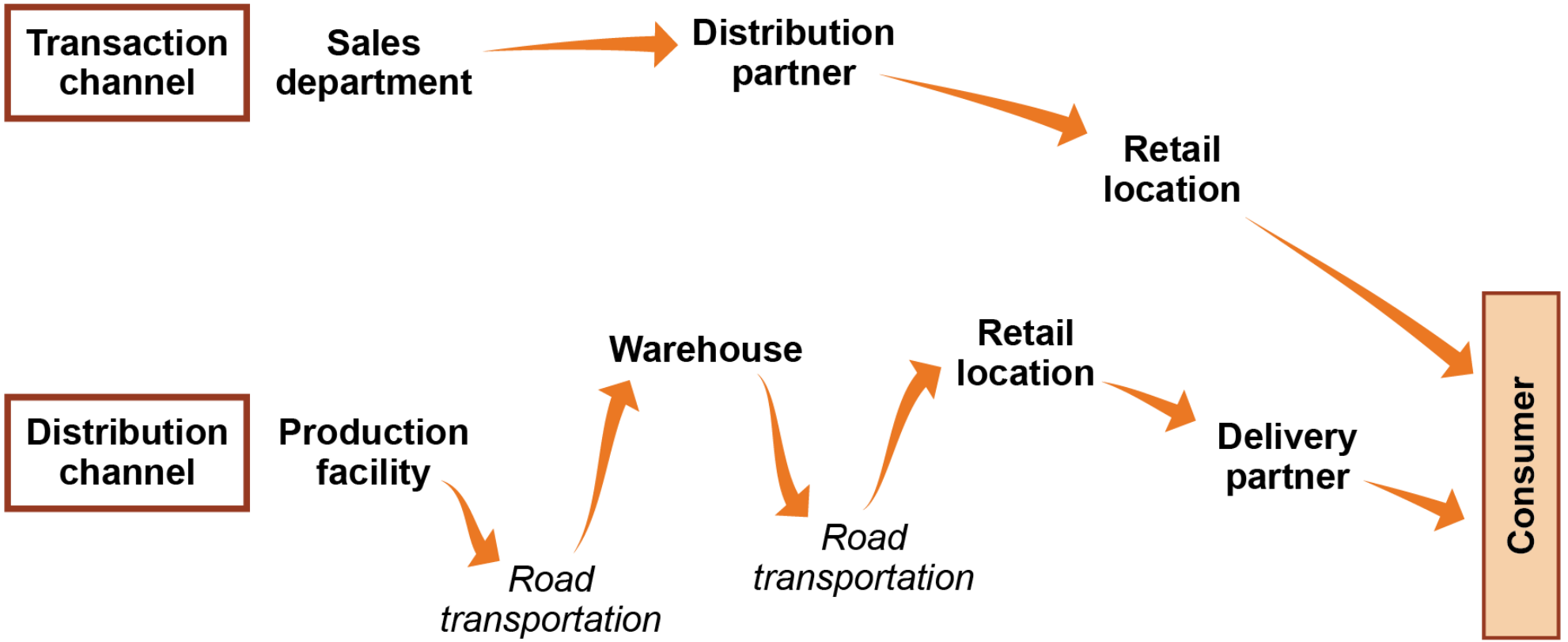
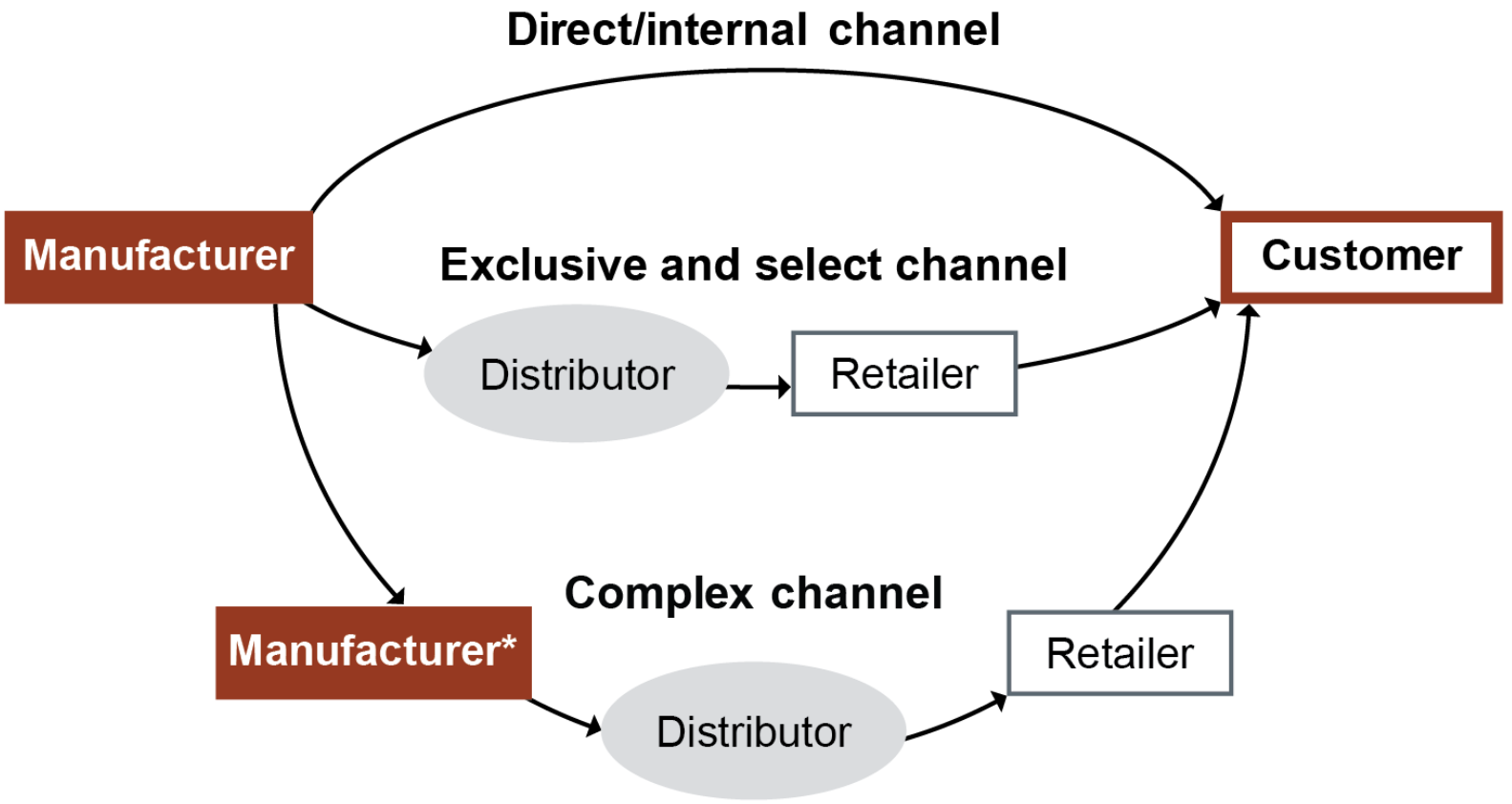
Section B Learning Objectives

- Sources of demand in master scheduling, including B2B and B2C
- Direct/internal; exclusive and select; and complex distribution channels
- Dependent and independent demand
- Key forecasting principles
- Forecast horizon and interval
- Forecasting process
- Qualitative and quantitative (extrinsic and intrinsic) forecasting methods
- Forecasting method pros and cons and selection criteria

Distribution and Transaction Channels

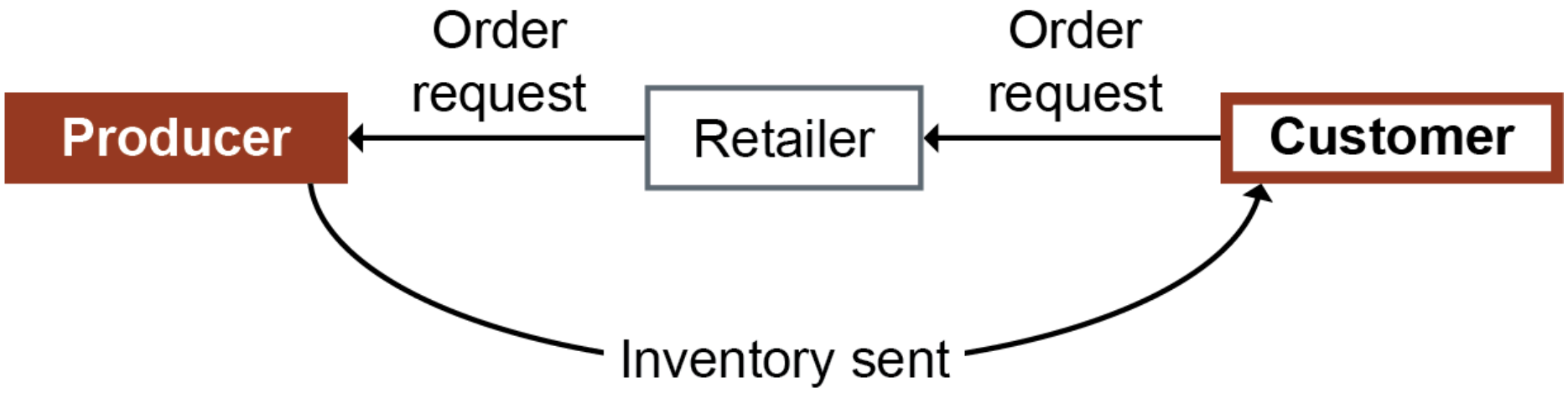


Distribution Channels



* Regional distribution centers owned by manufacturer

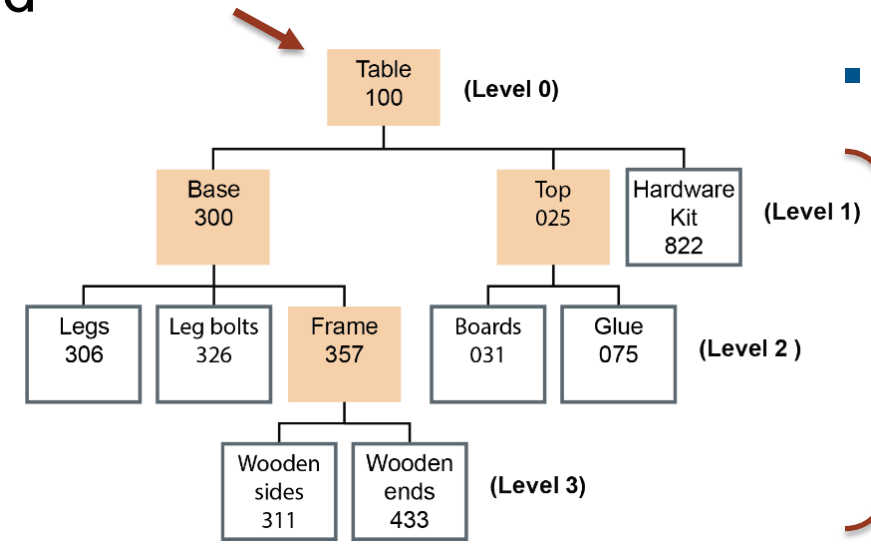
Producer Storage with Drop Ship



Dependent versus Independent Demand

Independent

- Demand for an item unrelated to the demand for other items
- Forecasted



Dependent

- Demand that is directly related to or derived from bill-of-material structure for other items or end products
- Calculated, not forecasted

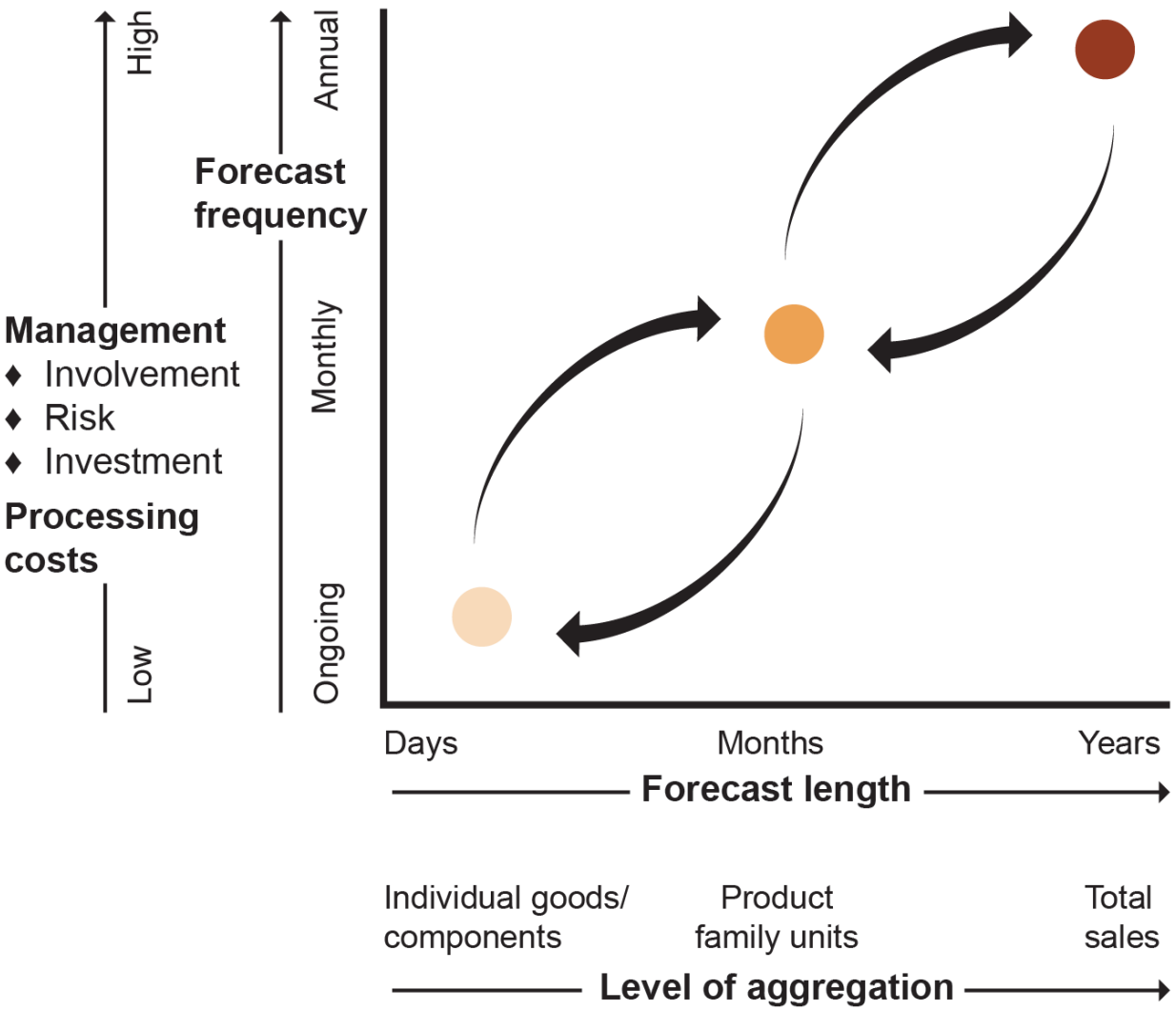
Item Forecasts: Sources of Forecast Data

Source	Demand Inputs
Demand management	▪ Channel family-level forecasts disaggregated to mix level, then end-item level at lowest level stocking points. ▪ Item forecasts for lowest level stocking points (using time series analysis, etc.) rolled up regionally to systemwide total for master scheduling.
Sales	▪ Sales force estimates for inventory storage locations. ▪ Replenishment needs for vendor-managed inventory.
Marketing	▪ Promotions that will cause demand spikes.
CRM	▪ Customer orders pending release to supplier. ▪ Changes in ordering patterns.
DCs and customers	▪ Reports of special events that will cause demand spikes. ▪ Recent anomalous purchases.

Forecasting Principles

- Forecasts are wrong most of the time.
- Forecast not complete without reliability/error metrics.
- Avoid forecasting: Use actual demand if able. Actual demand:
  - "Composed of customer orders (and often allocations of items, ingredients, or raw materials to production or distribution)."
  - Consumes the forecast.
- Aggregate demand to degree possible. Can aggregate:
  - Products (families)
  - Geographic areas
  - Time.
- Forecasts are more accurate in near term than long term.
- Match type to need:
  - Simpler is better.
  - Monitor routinely for appropriateness and quality.

Creating and Using a Forecast

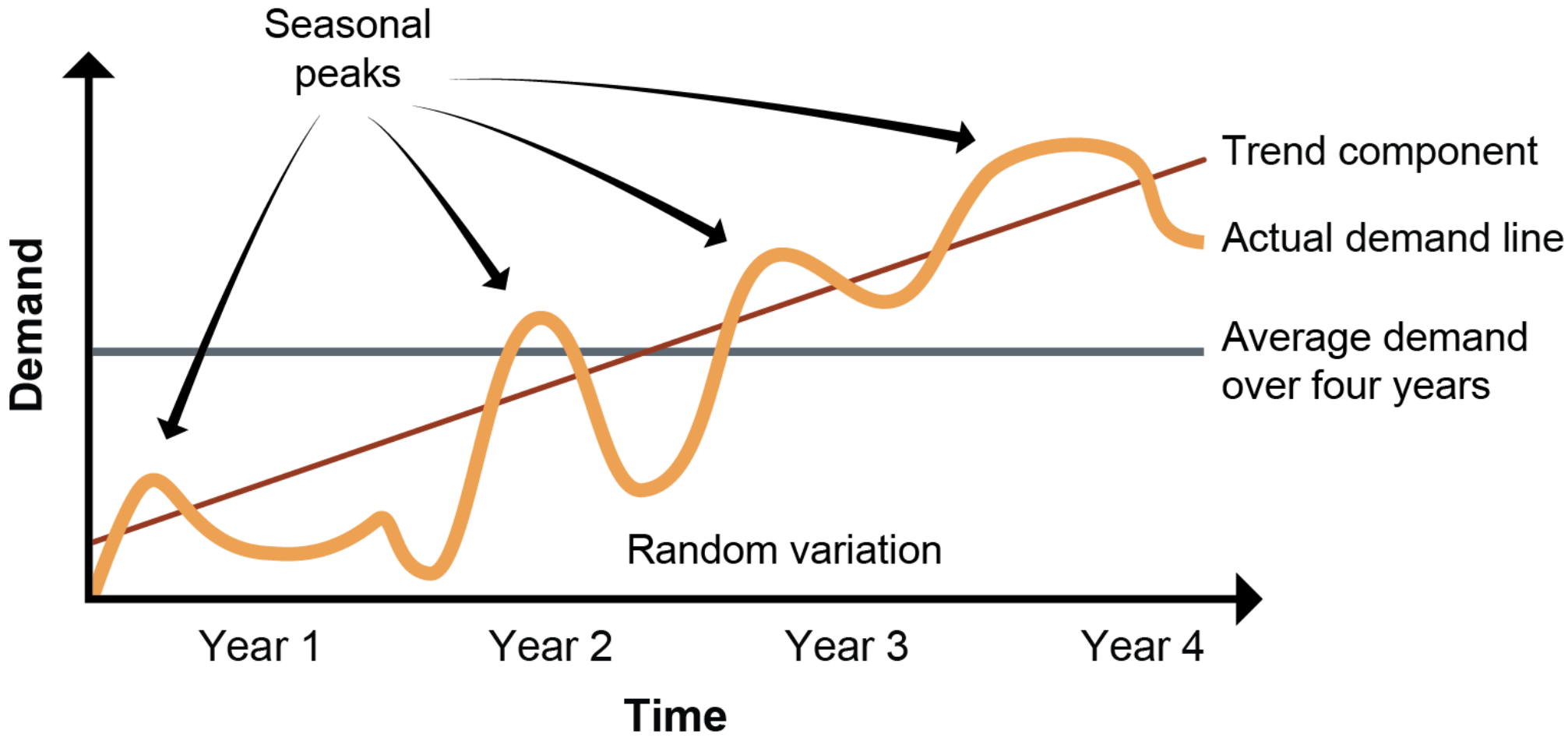


Strategic planning
Forecasting techniques
- Management judgment
- Economic growth models
- Regression

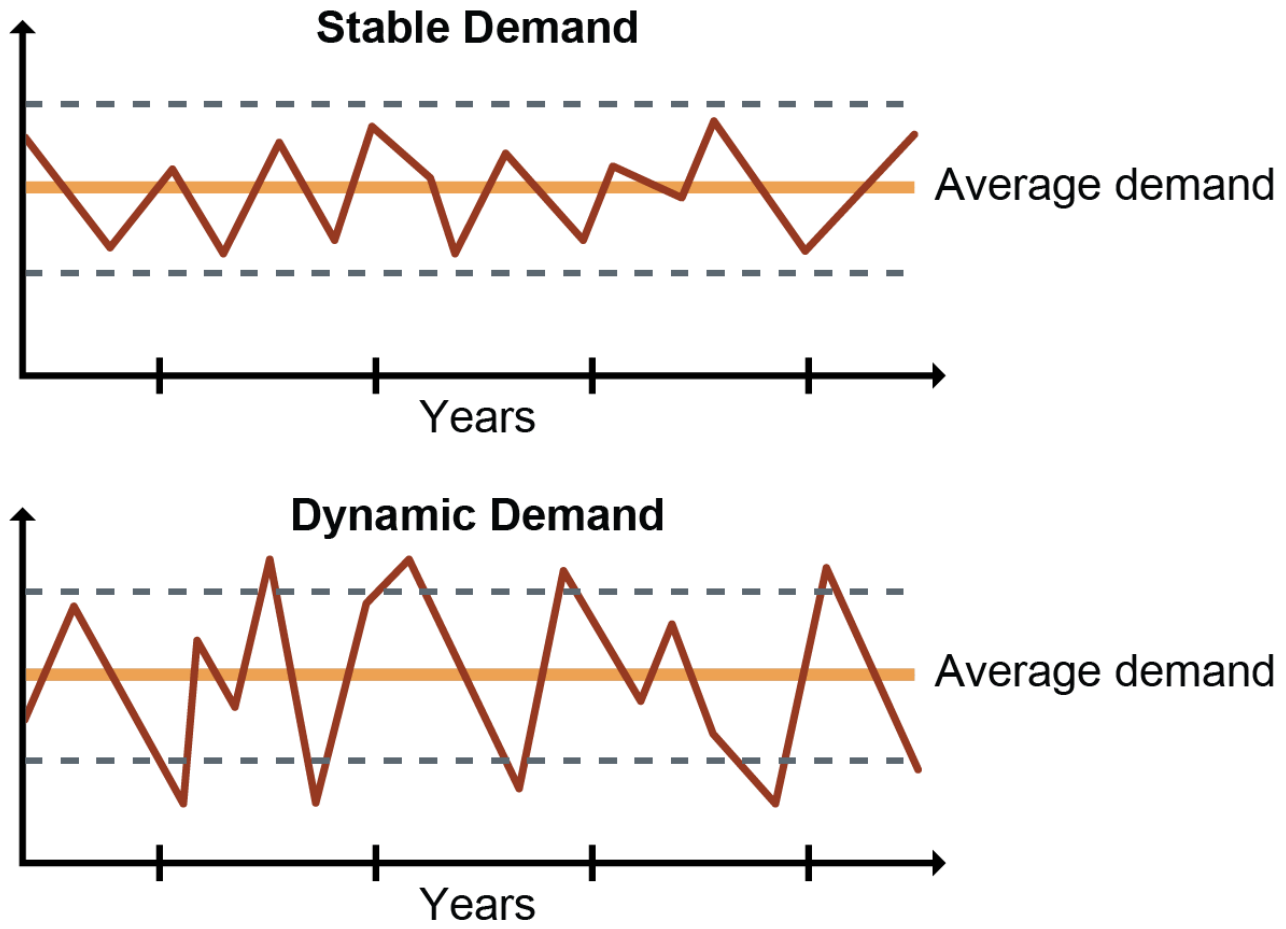
S&OP
Forecasting techniques
- Aggregation of detailed forecasts
- Customer plans
- Regression

Master production scheduling & control
Forecasting techniques
- Moving averages
- Exponential smoothing

Demand Patterns



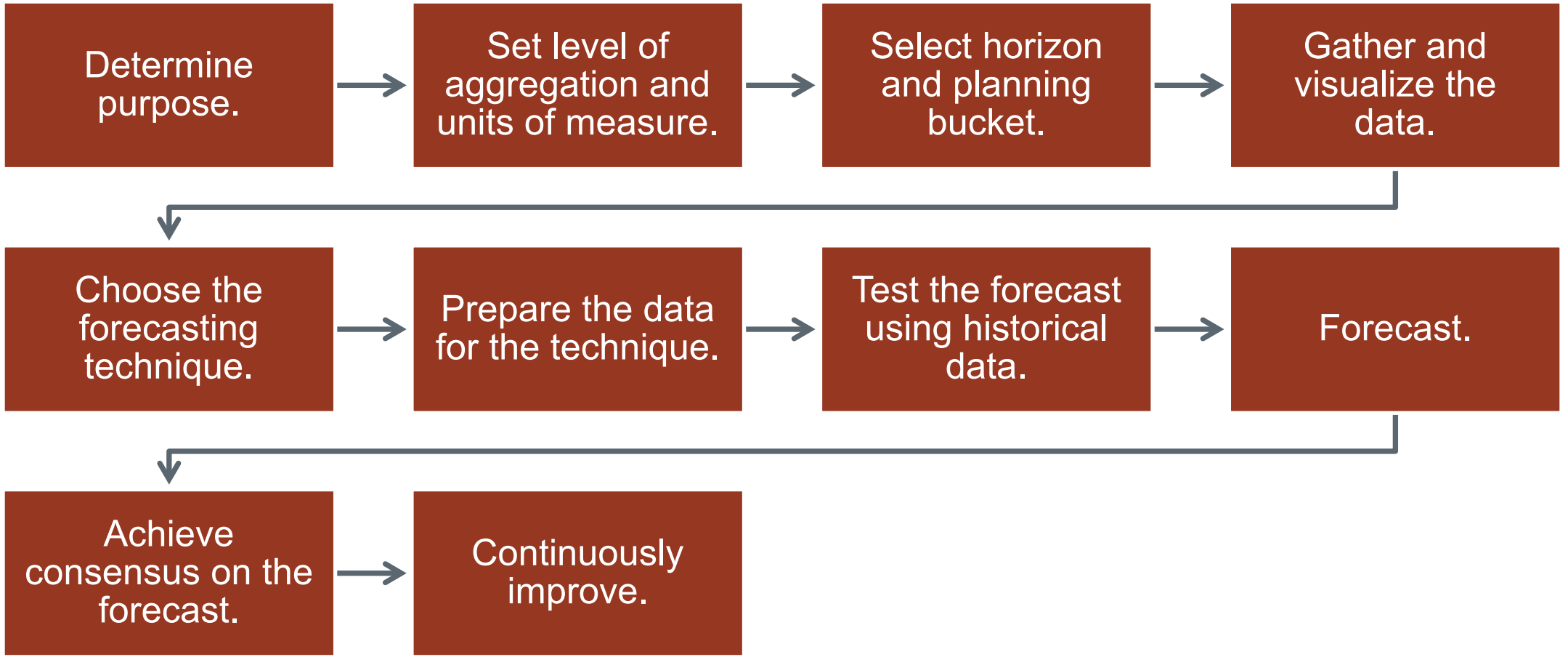
Stable versus Dynamic Demand



Demand Variation by Environment

Environment	Types of Uncertainty Requiring Forecasting
MTS	Variations in demand stated in forecasts for each inventory location
ATO	Variations in quantity, customer order timing, and product mix
MTO	Size of the backlog and the level of company resources needed to finish the engineering and make products per specifications
ETO	Hiring difficult-to-find design engineers and ordering materials with long lead times

Forecasting Process



Data Collection and Preparation Principles

- Forecast based on demand, not orders. Estimate demand from net sales, backorders, and requests that had to be turned away and/or filled from other plants.
- Collect data in needed format.
- Record related circumstances.
- Separate demand by customer segment.

Month	1	2	3	4	5	6	7	8	9	10	11	12	SUM
Segment A			6,000						6,000				12,000
Segment B	478	470	440	360	330	290	260	200	160	190	280	420	3,878
B avg.	323	323	323	323	323	323	323	323	323	323	323	323	
A+B avg.	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	

Information Needs by Environment

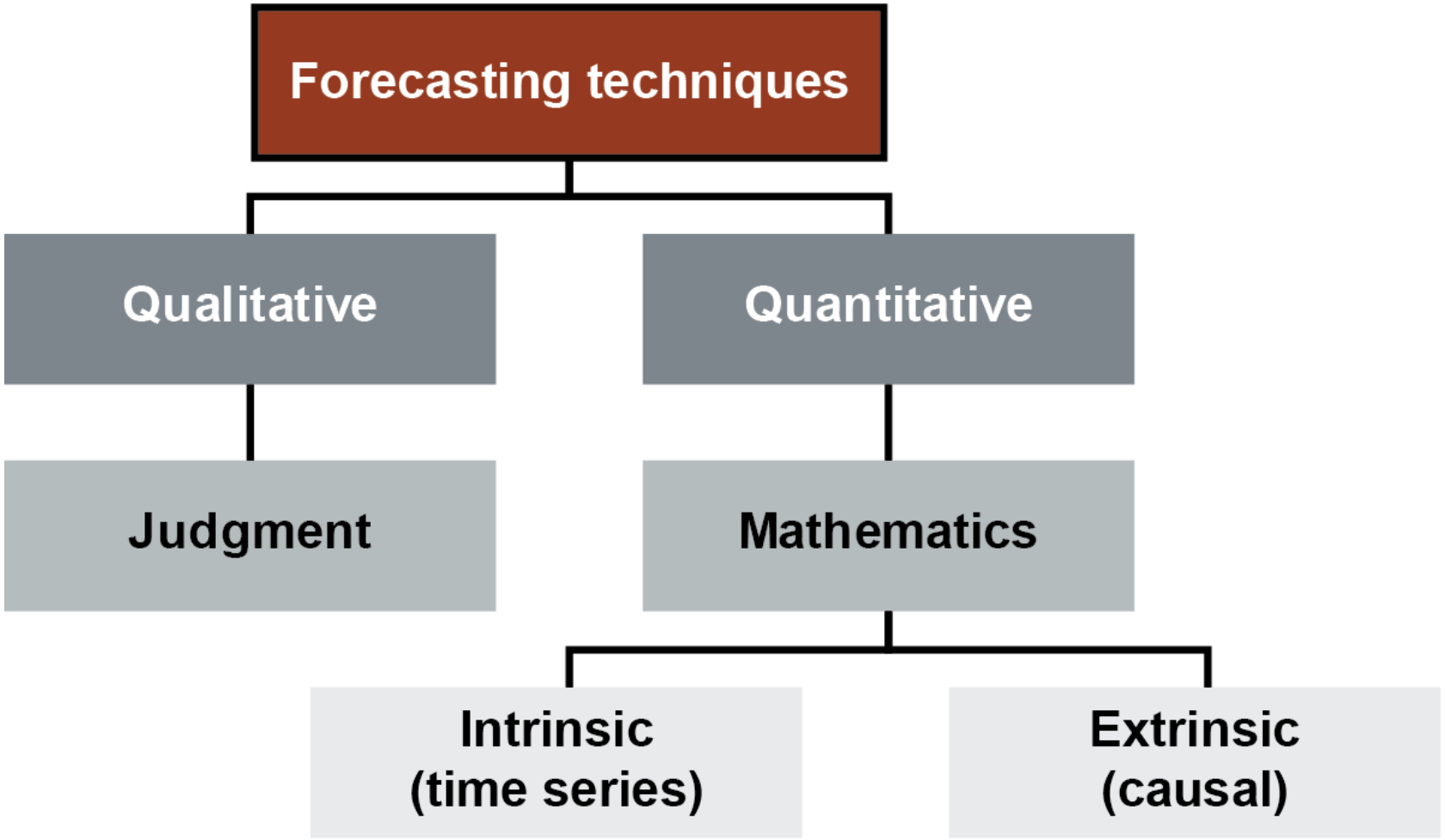
All manufacturing environments require sharing the forecast and other data among various functions, including sales and operations planning (S&OP), master scheduling (MS), and their customers.

- MTS uses forecasts for S&OP and actual demand for the master production schedule (MPS).
- ATO will use product family mix for S&OP and mix forecasts and actual demand for the MPS.
- MTO will need engineering detail for S&OP but final configuration for the MPS.
- ETO may use similar products with focus on engineering hours for S&OP and the MPS.

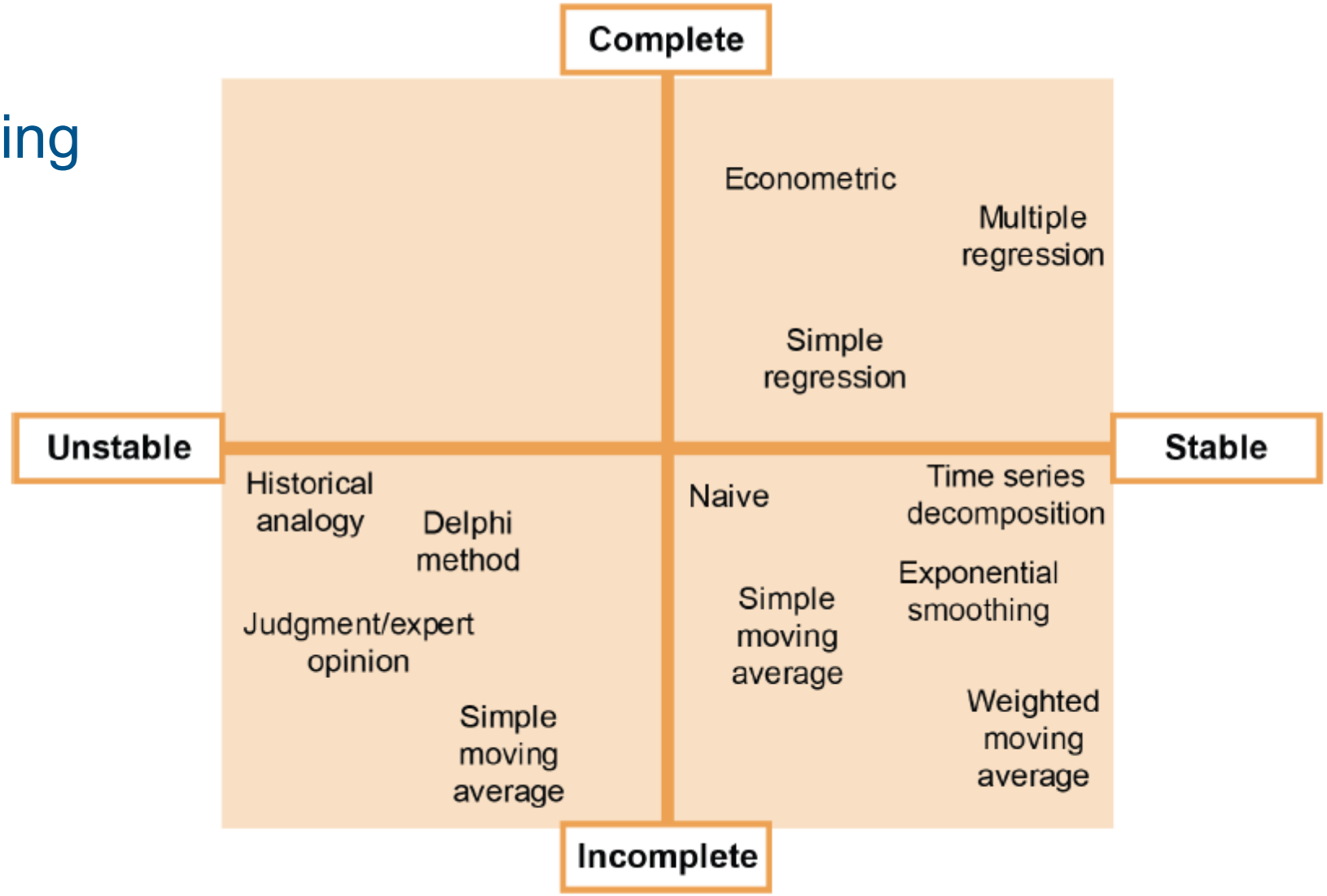
Forecast Audiences by Planning Level

Audience	Use
Business planning	▪ Set a direction. ▪ Plan product expansions and introductions. ▪ Evaluate strategic growth options.
S&OP	▪ Reconcile functional plans with planned output.
Master planning and scheduling	▪ Determine the number and timing of finished products. ▪ Provide input into rough-cut capacity plan.
Distribution requirements planning	▪ Plan inventory levels at DCs and inventory replenishment schedules.

Forecast Selection



Variables Affecting Selection of Forecasting Method



Qualitative Forecasting Methods

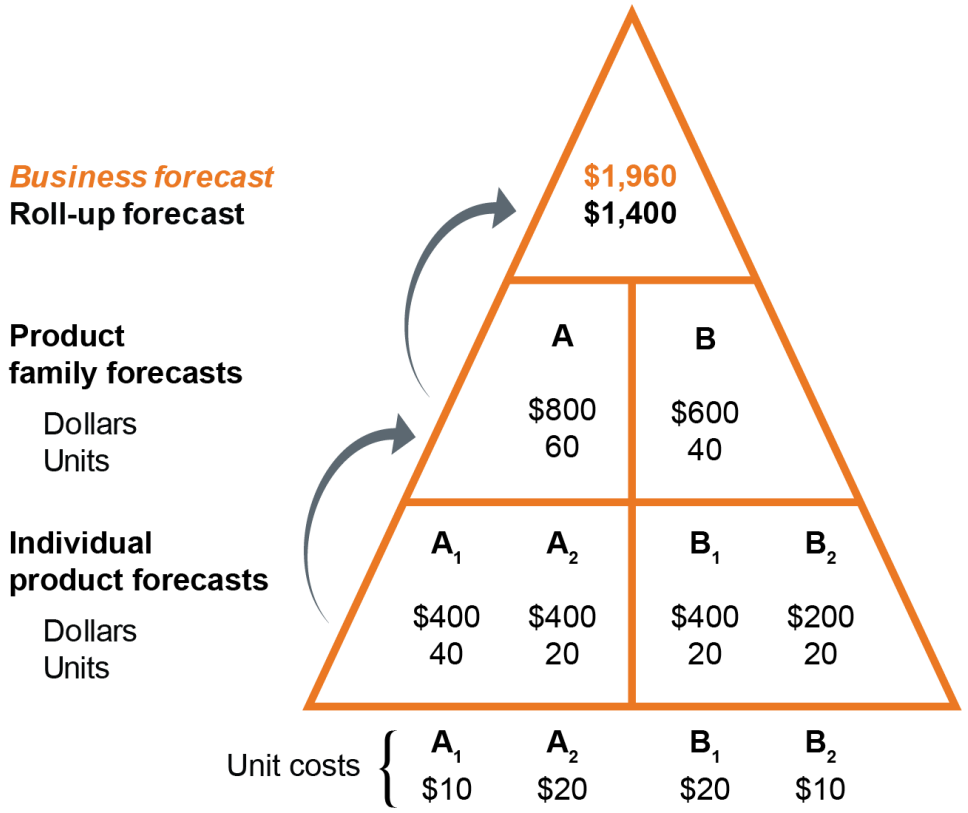
- Subjective approach based on intuitive or judgmental evaluation.
- Used when data is scarce, not available, or no longer relevant.
- May modify a quantitative forecast.
- Qualitative techniques:
  - Historical analogy (e.g., similar product)
  - Judgmental/expert opinion: experts forecast or modify quantitative forecast
  - Delphi method
  - Pyramid forecasting: hybrid of qualitative and quantitative

Qualitative Forecasting Methods

Delphi method

- Combines the opinions of experts in a series of iterations, each iteration being used to develop the next.
- Anonymity is maintained to avoid groupthink or “stake in the ground” mentality.

Pyramid forecasting



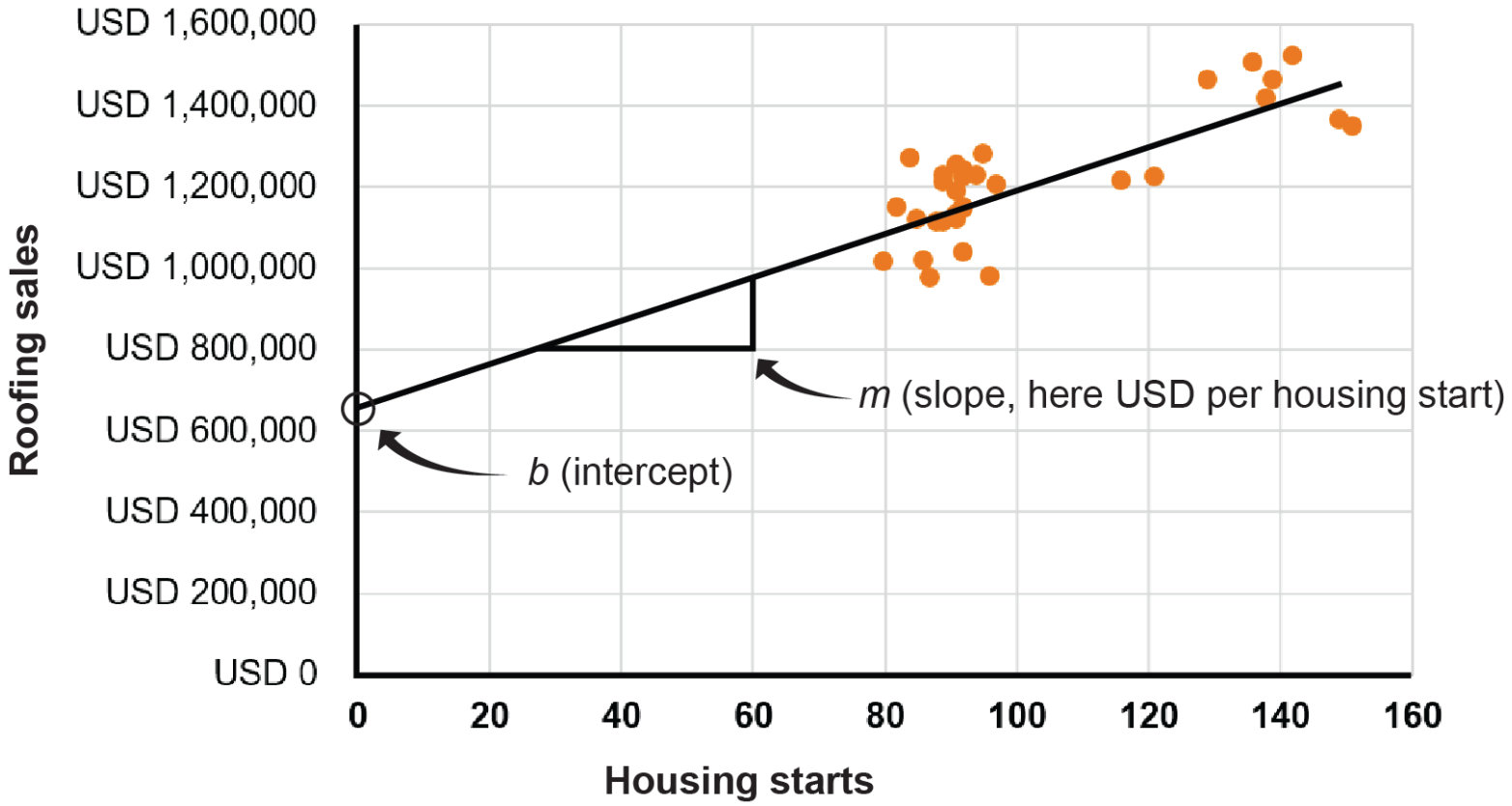
Quantitative Forecasting Techniques

Approach where historical demand data is used to project future demand.

Quantitative techniques:

- Extrinsic (causal)
- Intrinsic (time series)

Extrinsic (Causal) Techniques: Simple Regression



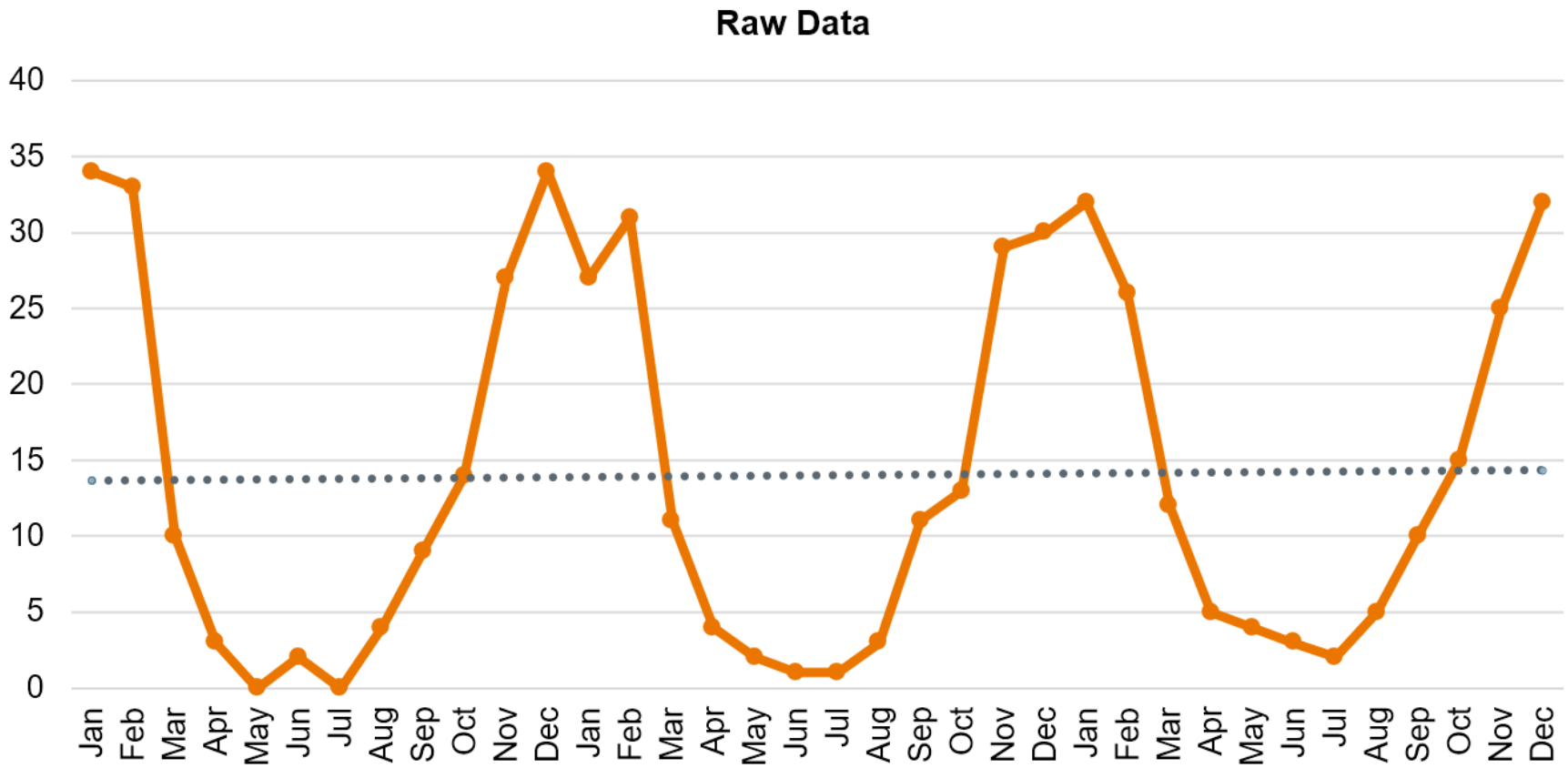
$$y = mx + b$$

Roofing Sales = (m × Prior Month's Housing Starts) + b

Quantitative Methods: Intrinsic (Time Series) Forecasting

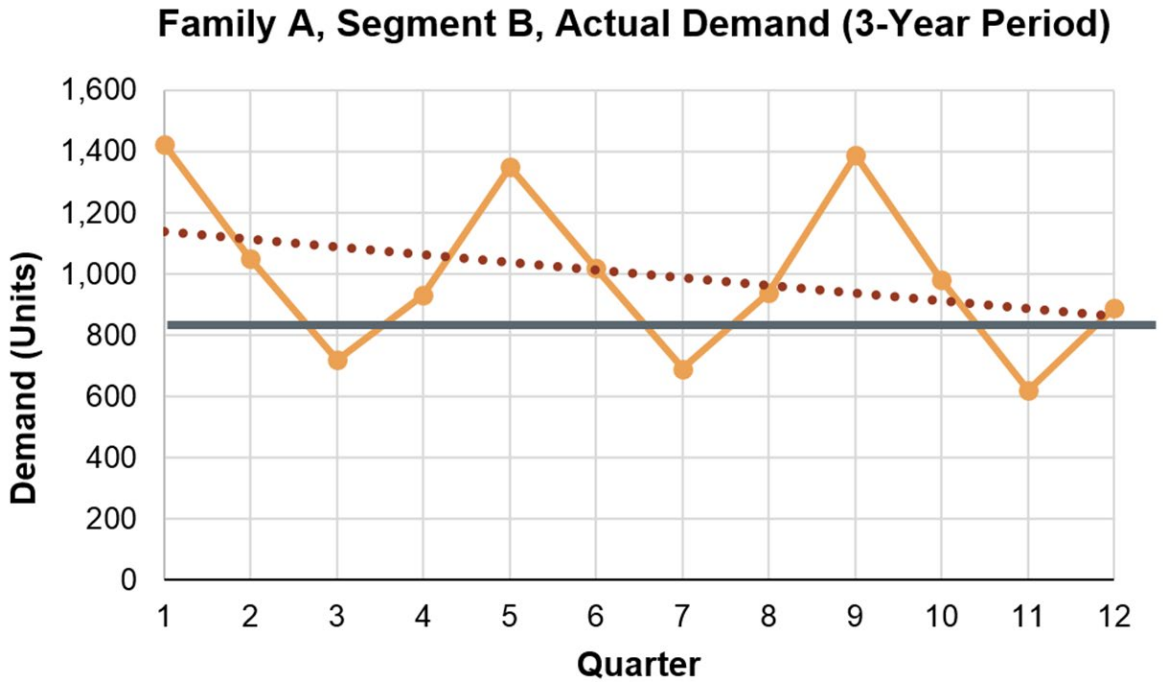
- Near-term past is good guide to near-term future.
  - True in current business environment?
- To deseasonalize, divide by period's seasonal index.
- After forecasting, multiply by seasonal index.
- Short- or medium-term: Get period's actuals; use for next period's forecast.
- All lag changes in trend and smooth out random variation.
  - Methods that make one factor better make the other factor worse.

Time Series Techniques: Visualizing



Seasonality: Deseasonalization and Seasonal Index

- Find period average demand, e.g., sum all Q1s and divide by number of Q1s.
- Find average demand for all periods, e.g., sum of quarterly averages divided by 4.



$$\text{Seasonal Index} = \frac{\text{Period Average Demand}}{\text{Average Demand for All Periods}}$$

Deseasonalized Demand

- Average is deseasonalized by definition.
- Apply seasonality: Multiply by period's seasonal index.
- Y4 forecast of 3,756 units/4 quarters = 939 units per quarter average.
- Q1 seasonal forecast = 1.387 x 939 = 1,302 units.

Actual Demand History					
	Year 1	Year 2	Year 3	Quarterly Average	Seasonal Index
Quarter 1	1,422	1,351	1,388	1,387	1.387
Quarter 2	1,050	1,018	980	1,016	1.016
Quarter 3	720	691	620	677	0.677
Quarter 4	930	940	890	920	0.920
Sum	4,122	4,000	3,878	4,000	4.000
Average Demand (Qtr. Avg. Sum/4) =				1,000	

Seasonal Index Exercise

Sales Information						
Quarter	1	2	3	4	Total	Avg.
Year 1	30	600	1,650	120	2,400	600
Year 2	36	635	1,713	134	2,518	630
Year 3	42	670	1,788	150	2,650	663
3-Year Average	36	635	1,717	135	2,523	631
Seasonal Index (3 decimal places for rounding purposes)	0.057	1.007	2.723	0.214		
Year 4 (Quarterly avg. x 3-yr. index)	54	954	2,580	202	3,790	948

$$\text{Seasonal Index} = \frac{\text{Period Average Demand}}{\text{Average Demand for All Periods}}$$

Moving Averages

$$\text{Moving Average} = \frac{\text{Sum of Demand for Most Recent Set of Periods}}{\text{Number of Periods}}$$

$$\text{Weighted Moving Average} = \frac{(1 \times \text{Period 1}) + (2 \times \text{Period 2}) + (3 \times \text{Period 3})}{\text{Sum of Weights } (1 + 2 + 3 = 6)}$$

Exponential Smoothing

- Weighted average of latest period demand, forecast.
- Alpha (α) is smoothing constant between 0.0 and 1.0 (usually set from 0.0 to 0.3).
- Lower alphas lag more and smooth more.

New Forecast = (α × Latest Demand) + ((1 − α) × Previous Forecast)

New Forecast (Deseasonalized) = (0.3 × 967) + (0.7 × 973) = 971

Qtr.	Deseasonalized Demand	Deseasonalized Forecast	0.3 Exp. Forecast
Y3-Q4	967	973	
Y4-Q1		**971**	× 1.387 = **1,347**

Q1 seasonal index

Exponential Smoothing Forecast Exercise 1

- Prepare an exponential smoothing forecast for June.
  - May data: actual demand = 220; forecast = 200.
  - Calculate the forecast for June using a smoothing constant (α) of 0.20.
- New forecast = (α) (latest demand) + (1 – α) (previous forecast)

(0.2) 220 + (0.8) 200 = 44 + 160 = 204

Exponential Smoothing Forecast Exercise 2

- Prepare an exponential smoothing forecast for July.
  - June data: actual demand = 240
  - Calculate the forecast for July also using a smoothing constant (α) of 0.20.
- New forecast = (α) (latest demand) + (1 – α) (previous forecast)

(0.2) 240 + (0.8) 204 = 48 + 163 = 211

Time Series Techniques: Exponential Smoothing Exercise

- Demand for a new product is rising faster than forecasts based on 0.2 alpha value exponential smoothing. Would you recommend use of a higher or lower alpha value, and what would your forecast be for September?

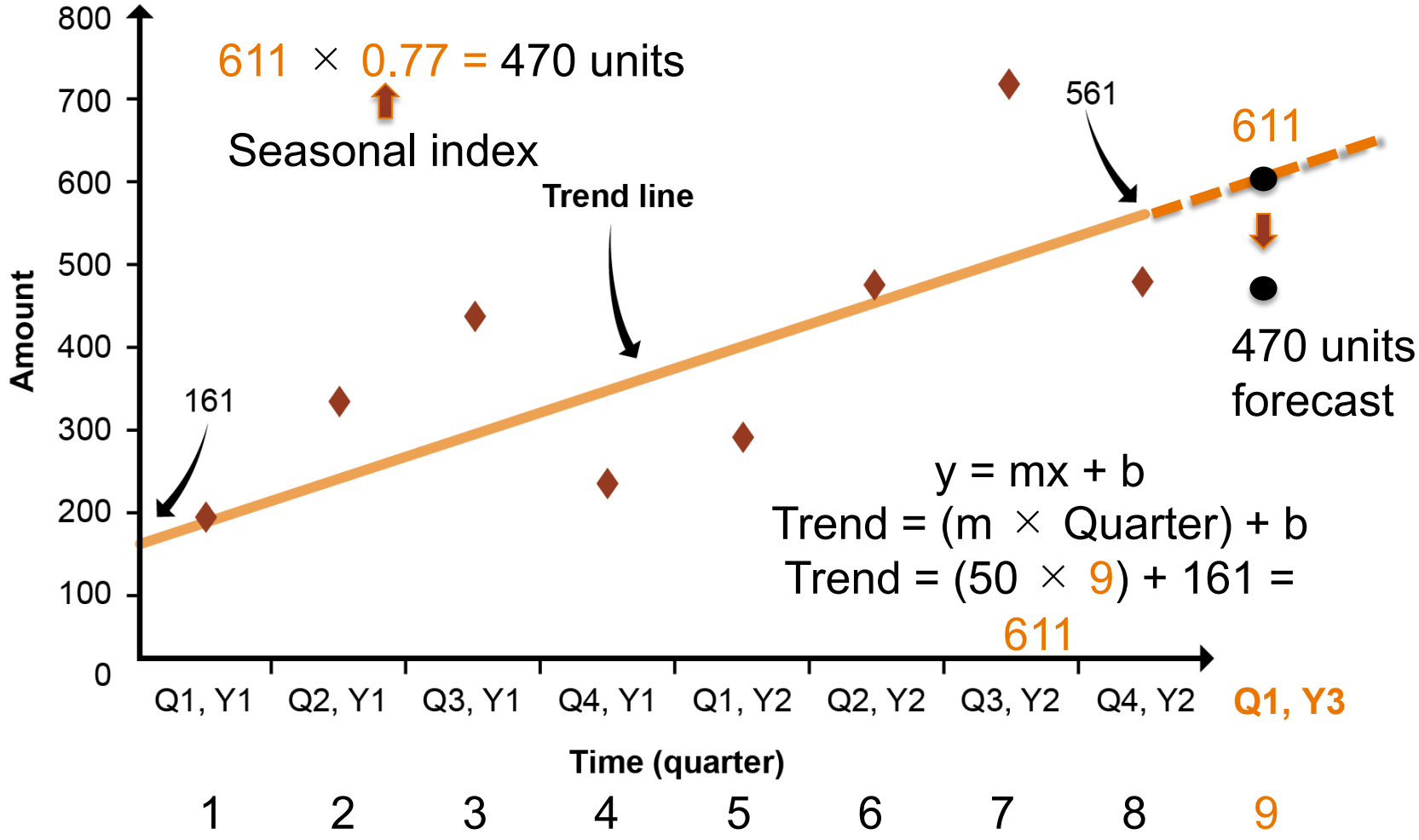
Demand	May	June	July	August	September
Forecast	200,000	204,000	211,200	221,160	
Actual	220,000	240,000	261,000	275,000	

- Demand for a consumer product appears to be random with low variability. Do you recommend a high, medium, or low alpha value?

Period	1	2	3	4	5	6	7	8
Demand	95	91	104	95	106	89	94	110

- If demand shows a definite declining trend, would you recommend a high, medium, or low alpha value?

Decomposition: Trend and Seasonality



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SECTION C:
FORECAST PERFORMANCE

APICS

ASCM

Section C Learning Objectives

- Evaluating forecast performance
- Benefits of forecast accuracy
- Bias versus random variation
- Mean absolute deviation (MAD) and other forecast error metrics
- Tracking signal for identifying forecasts to evaluate
- Bullwhip effect on supply chain instability
- Collaborative planning, forecasting, and replenishment (CPFR®)

Forecast Evaluation Road Map

Why track error rates

- Improve forecasts.
- Know how much reliance to place on forecast, e.g., how much safety stock?
- Detect bias.
- Get quantitative data on actual customer service level.
- See forecaster willingness to stand by results.

Benefits of accuracy

- Customer satisfaction (timely)
- Customer loyalty
- Less safety stock or safety lead time
- Understand evolving customer product demands

Evaluation of Forecast Performance

- Extrapolation
- Mean
- Median
- Mode
- Normal distribution
- Outlier
- Probability distribution
- Sample
- Sampling distribution

Bias Versus Random Variation

- Bias: consistent deviation from mean in one direction.
- Biased means actual and forecast diverge over time.
- Unbiased forecast error root cause = random variation.

	Bias			Random Variation		
Month	Actual	Forecast	Deviation	Actual	Forecast	Deviation
1	70	100	-30	105	100	5
2	150	100	50	94	100	-6
3	120	100	20	98	100	-2
4	60	100	-40	104	100	4
5	160	100	60	103	100	3
6	120	100	20	96	100	-4
Cumulative	680	600	80	600	600	0

Deviation Versus Forecast Error

- Deviation = Actual Demand − Forecast.
- Plus or minus sign shows direction.
- Positive and negative deviations cancel each other out.
- Error (absolute deviation, no + or −) shows full impact.

Qtr.	Actuals	3-Qtr. Moving	Deviation	Error
Y2-Q3	691	674	17	17
Y2-Q4	940	919	21	21
Y3-Q1	1,388	1,408	-20	20
Y3-Q2	980	1,031	-51	51
Y3-Q3	620	674	-54	54
Y3-Q4	890	884	6	6
		SUM	**-80**	**169**

*

Mean Absolute Deviation

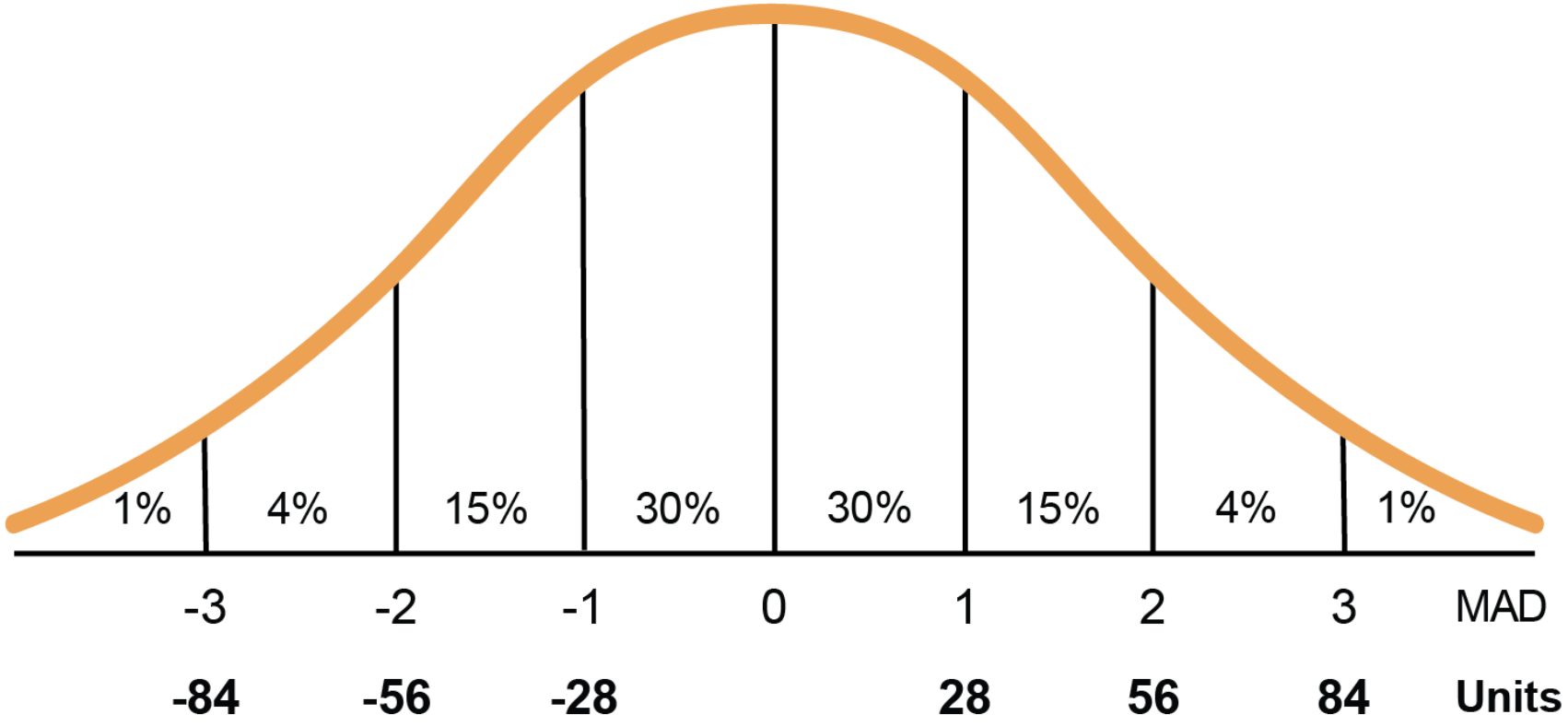
$$MAD = \frac{\sum | \text{Actual} - \text{Forecast} |}{\text{Number of Periods}}$$

$$MAD = \frac{(17 + 21 + 20 + 51 + 54 + 6)}{6} = \frac{169}{6} = 28 \text{ Units}$$

Quarter	Actual Demand		3-Qtr. Moving		3-Qtr. Moving Error		
Y2-Q3	691	−	674	=	17		
Y2-Q4	940	−	919	=	21		
Y3-Q1	1,388	−	1,408	=	20		
Y3-Q2	980	−	1,031	=	51		
Y3-Q3	620	−	674	=	54	**SUM:**	169
Y3-Q4	890	−	884	=	6	**MAD:**	28

Mean Absolute Deviation

MAD in units for 3-quarter moving average forecast



Mean Squared Error and Mean Absolute Percentage Error

$$\text{MSE} = \frac{\text{Sum of (Errors for Each Period)}^2}{\text{Number of Forecast Periods}}$$

$$\text{MAPE} = \frac{\sum \left(\frac{|\text{Actual} - \text{Forecast}|}{\text{Actual}} \right) \text{ [\%]}}{\text{Number of Periods}}$$

Tracking Signal

- One-number bias assessment
- Numerator not absolute
  - Cumulative deviation
- Implement contingency plan to manage demand variations (e.g., using safety stock) and maintain customer service level

$$\text{Tracking Signal} = \frac{\text{Algebraic Sum of Forecast Deviations}}{\text{MAD}} = \frac{-80}{28} = -2.83^*$$

Standard Deviation and WAIT

Standard deviation

- Widely used to plan for fluctuations
- Dispersion of data around mean
  - Actual versus average (forecast error not used)
  - High variability: more safety stock

$$\text{Standard Deviation} = \sqrt{\frac{\sum(\text{Actual} - \text{Average})^2}{n - 1}}$$

WAIT for forecast accuracy

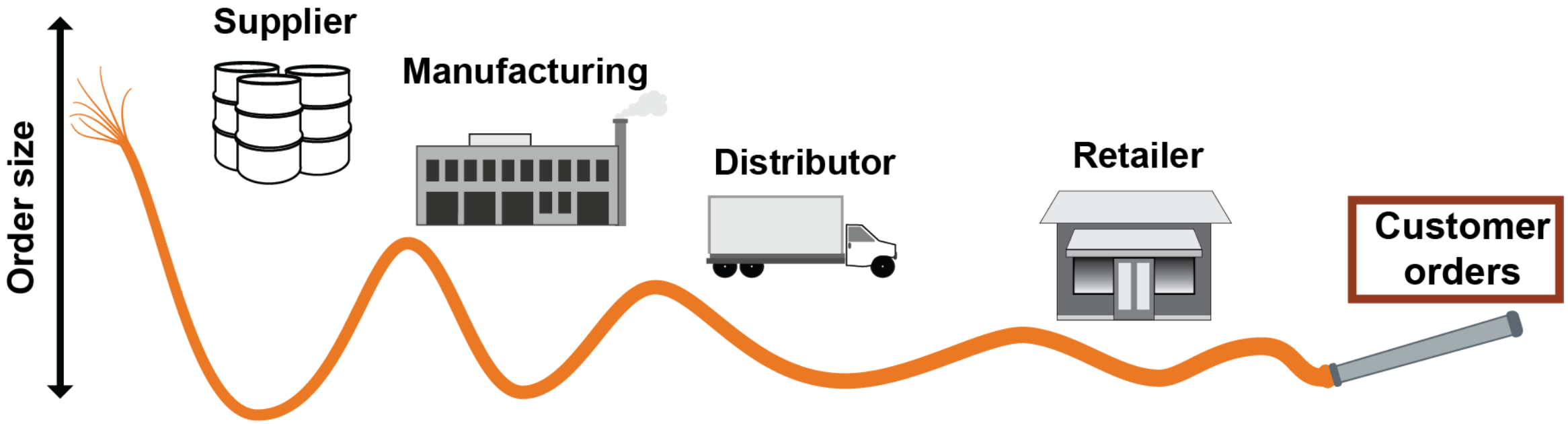
- "Within allowable item tolerances"'
- How much error is problematic?
  - "Hit" = within tolerance
  - "Miss" = outside tolerance

$$\text{Forecast Accuracy} = \frac{\sum(\text{Number of Hits})}{\sum(\text{Number of Hits} + \text{Number of Misses})} \times 100\%$$

Supply Chain Dynamics

Bullwhip effect

Extreme change in upstream supply position generated by small change in downstream demand



Bullwhip Effect Example

Period	Supplier 3 (Plastic Liners)		Supplier 2 (Covers)		Supplier 1 (Mattresses)		Manufacturer of Cribs		Retail Demand
	Prod.	B/E	Prod.	B/E	Prod.	B/E	Prod.	B/E	
1	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000
2	200	1,000/ 600	600	1,000/ 800	800	1,000/ 900	900	1,000/ 950	950
3	1,800	600/ 1,200	1,200	800/ 1,000	1,000	900/ 950	950	950/ 950	950
4	600	1,200/ 900	900	1,000/ 950	950	950/ 950	950	950/ 950	950

Controlling the Bullwhip Effect

Causes

- Demand forecast updating and orders rather than demand
- Order batching
- Price fluctuation
- Rationing and gaming

Focus of solutions

- Better accuracy through shared data
- Technology and collaboration to make orders smaller and more frequent
- Agreement on promotions/less of them
- Less forecasting (e.g., DDMRP)
- Historical data to improve decisions
- Less ability to return unsold product
- Vendor-managed inventory

CPFR® Model

Manufacturer Tasks	Collaboration Tasks	Retailer Tasks
Strategy & Planning		
Account Planning	Collaboration Arrangement	Vendor Management
Market Planning	Joint Business Plan	Category Management
Demand & Supply Management		
Market Data Analysis	Sales Forecasting	POS Forecasting
Demand Planning	Order Planning/Forecasting	Replenishment Planning
Execution		
Production & Supply Planning	Order Generation	Buying/Re-buying
Logistics/Distribution	Order Fulfillment	Logistics/Distribution
Analysis		
Execution Monitoring	Exception Management	Store Execution
Customer Scorecard	Performance Assessment	Supplier Scorecard